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Predicting Success of Developmental and Core Mathematics Students at East Tennessee State University

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To the Graduate Council:

I am submitting herewith a dissertation written by Daryl Lynn Stephens entitled "Predicting Success of Developmental and Core Mathematics Students at East Tennessee State University." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Vena M. Long, Major Professor

We have read this dissertation and recommend its acceptance:

Donald J. Dessart, C. Edward Roeske, Edward Counts

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

Donald J. Dessart

C. Edward Roeske

Edward Counts

Accepted for the Council:

Anne Mayhew

Vice Chancellor and Dean of Graduate
Studies

(Original signatures are on file with student records.)

Predicting Success of Developmental and Core Mathematics Students at East Tennessee State University

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Daryl Lynn Stephens

December, 2005

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Acknowledgments

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Abstract

Current regulations in the Tennessee Board of Regents system place students into developmental or regular classes based solely on scores on either the ACT or COMPASS. This study examined whether a combination of other readily available factors might better predict a student's success.

Students at East Tennessee State University taking elementary algebra, intermediate algebra, and probability and statistics (the core math class at the university) were surveyed in Fall, 2004, to find out when they took their last mathematics class in high school and what mathematics courses they took in high school. Other variables were obtained from the student information system when available: age; ACT/SAT composite, mathematics, and reading scores or COMPASS reading, arithmetic, and intermediate algebra scores; overall high school GPA, and final grade in the course they were taking. End-of-semester grades (the dependent variables) were correlated with the other independent variables. Stepwise multiple regression equations were attempted for each course – one for students with ACT scores and another for students with COMPASS scores – to see whether several of the independent variables together could predict these grades.

For students in elementary algebra, end-of-course grades were significantly correlated with COMPASS reading scores and overall high school GPA. Grades in intermediate algebra were significantly correlated with ACT

mathematics and English scores, COMPASS arithmetic and intermediate algebra scores, number of college preparatory mathematics classes taken in high school, and overall high school GPA. Grades in probability and statistics were correlated with the same variables as intermediate algebra except for COMPASS reading.

Regression equations to predict grades were possible for traditional age students (students with ACT scores) in all three courses with high school GPA and a few other scores as independent variables. For nontraditional students, the regression equations were only possible for intermediate algebra and statistics using COMPASS arithmetic scores. No regression equation was possible for elementary algebra.

The equations found could be used to target students who might be in danger of failing and be referred to additional sources of help. It is further recommended that study be repeated for spring and summer semesters.

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Chapter 1

Introduction

Since at least the 1840s, colleges and universities have admitted students who are not completely prepared to begin taking college-level courses. In some cases, institutions created special programs and courses, now called developmental courses, to help underprepared students catch up so they would be ready to take college-level classes. Such programs grew in and out of favor over the ensuing years, but never completely disappeared.

Salter and Noblett (1994) identify several possible reasons that students may need to take developmental courses, especially in mathematics. Some students took a college preparatory curriculum while in high school, but by the time they took admissions tests, they no longer retained the information and skills from those high school courses. Some of those may have had gaps of one to forty years between their last high school mathematics class and their matriculation to college. Others may not have taken their high school mathematics experience seriously, and consequently never completely learned algebra as well as they would have been expected to. Still other students had absolutely no idea that they would ever attend college, and therefore never took a college preparatory curriculum. Some of the students are the first in their family to attend college; as a result, their family is unable to help the student

make the transition to college life. Such underprepared students often need one or more developmental courses.

Not all students entering college are underprepared. Some come to college with entrance scores that indicate they are ready to begin with college level mathematics courses. Others complete the prescribed developmental mathematics sequence and are prepared for college-level work. Nevertheless, a sizeable percentage of students taking core mathematics classes – that is, mathematics courses required for students to graduate – fail their core mathematics class the first time they take it.

The Problem

Admissions and placement procedures for colleges in the Tennessee Board of Regents system (TBR) have changed several times recently. In previous years, students entering TBR schools who had American College Test (ACT) mathematics scores below 19, or were over the age of 22, were given the Academic Assessment and Placement Program (AAPP), a standardized, multiple-choice paper-and-pencil test, to determine whether they needed to begin their mathematics courses in prealgebra, elementary algebra, or intermediate algebra. In 2000 the placement testing program was switched to use ACT's Computerized Adaptive Placement Assessment and Support System (COMPASS) test, taken on a computer in a testing center (Bader & Hardin, 2002). During a time of state budget instability in 2002, the Regents changed the placement procedure again. For students who took the ACT, their ACT

mathematics subscores would be used as the primary method to determine whether a student should be placed into developmental studies courses, although individual institutions could continue to use secondary instruments such as COMPASS, end-of-course tests, or other instruments for secondary placement (Treva Berryman, personal communication, July 8, 2002). New guidelines for developmental studies programs, known as A-100 (TBR, 2003), require that students with valid ACT or SAT scores less than three years old be placed into developmental courses based on scores from the mathematics portion of that assessment, while students without such scores would take COMPASS for placement purposes.

Treva Berryman (personal communication, July 8, 2002), Associate Vice Chancellor for Academic Affairs at TBR, believes that the lack of a secondary assessment instrument would result in many more students being placed in the developmental studies program. In addition, many professionals in the field of developmental education feel that neither the COMPASS nor the ACT are sufficient to act as placement instruments alone, even though the COMPASS is designed as a placement instrument, and the ACT was restructured in the mid-1990s to be useful to place entering students in mathematics and other classes (ACT, 1997). In an online forum of developmental mathematics faculty, several members of the Mathematics Special Professional Interest Network of the National Association for Developmental Education (NADE Math SPIN) have

expressed concern over the structure and wording of items and directions in the COMPASS test when used as a sole placement instrument (e.g., Diehl, 2002).

As state funding for higher education remains relatively stagnant or even decreases, and with rumors circulating of eventual enrollment caps on universities, the need seems greater to use readily-available data on incoming students to predict a student's subsequent success in developmental and core mathematics classes. Developing prediction equations for a student's grades in a developmental course could potentially be useful both to admissions personnel and to academic advisors. Already the office of undergraduate student advisement at East Tennessee State University has begun research to develop such prediction equations for remedial and developmental courses (McLean & Williams, 2003) to refine the placement process.

Purpose

The purpose of this study is to develop a model for predicting success (as measured by end-of-course grade) in developmental mathematics courses and the core mathematics course of probability and statistics, given readily obtainable information about the student which does not cost money or take extra time (as opposed to various commercially available assessment instruments such as mathematics anxiety scales). The study will use multiple regression to develop an equation that will predict a student's grade in each course given the student's age at the beginning of the term, years since last high school mathematics course, ACT composite score and mathematics and other

section scores (or SAT-I equivalent) for students who have them and COMPASS scores for those who do not, high school grade point average, and number of years of college-preparatory high school classes completed in mathematics. These equations could possibly be used to enhance the placement process at the university or target students who might need extra help in order to succeed.

Importance of the Study

The present study looks to meet some current needs to help students at East Tennessee State University who are taking core or developmental mathematics courses. Historically, MATH 1530, the core (degree requirement) mathematics course at ETSU for most students, has had a high failure rate, although the success rate has increased in the last year due to a number of innovations including a hands-on computer laboratory component (Price, 2004). The university has provided online and in-person tutoring and Supplemental Instruction for MATH 1530 because it is deemed a high-risk course. Information gained from this study might help develop a profile of the kinds of students who should be targeted for special followup.

Students placed in developmental mathematics courses, because their entrance scores are below the usual expected levels, could be considered especially at risk of failure and dropping out. In the past, a separate division of developmental studies was in place at ETSU and had two full-time and one part-time advisors to follow up on particularly at-risk students in math, writing, and reading. This division was eliminated on July 1, 2003, as one of several cost-

cutting measures, and advising of developmental students was transferred to the office of undergraduate advisement without adding additional personnel to that office (“Elimination of office of developmental studies,” 2003). Time for advisors to work with individual students is therefore reduced, so a low- or no-cost way of identifying developmental students who might be at risk of failure before the beginning of the semester could potentially boost student achievement.

Although a number of studies exist which find factors influencing success in core courses such as college algebra, precalculus, calculus, and mathematics survey courses, virtually no similar studies seem to have been done so far on students in an introductory probability and statistics course which counted for general education requirements.

Assumptions

For this study, the assumption must be made that it is possible to predict a students’ success in developmental or core mathematics courses based at least partly on data known or obtainable about the students before matriculation. It is also assumed that information collected about these mathematics students, both self-supplied information and data entered into the online student information system, is accurate.

Limitations

Each state has a different method of determining whether or not a student should be placed into developmental studies courses, and each state's regulations regarding developmental studies programs is different. The state of Tennessee has a mandatory placement program in place — and in fact there is now a standard set of objectives for developmental mathematics courses across all TBR institutions — but not all states require mandatory placement into developmental courses. Within the Tennessee Board of Regents system, demographic characteristics of student populations from one university or college to another vary. As a result, conclusions made in this study can only be applied with any degree of confidence to students at East Tennessee State University.

Furthermore, the conclusions of this study may only apply to students at ETSU enrolled in the fall semester. Students enrolled in developmental mathematics courses in the fall semester may as a whole make different grades from students enrolled in fall or summer. Research done by Hopkins and Stephens (2002) found significant differences in average grades between summer, fall, and spring semesters over a five-year period at ETSU for the two developmental mathematics courses. Grades in fall tended to be somewhat higher than spring grades in the same courses, and summer grades tended to be higher than fall grades.

Information about students taking probability and statistics may not apply to students in core mathematics classes at other universities, because most colleges and universities, even in the TBR system, do not designate this course as the preferred core mathematics course for most students majoring in a field other than mathematics or natural sciences.

Delimitations

This study is delimited to students at East Tennessee State University who were enrolled in a developmental mathematics course or probability and statistics course in the fall semester of 2004. Both traditional and nontraditional students are included in the population studied. All students in the course were considered part of the population, whether they were first-semester entering students or had taken other college mathematics courses (or even the same one) previously. Due to more complicated rules regarding informed consent, however, any students enrolled in these courses who were under the age of 18 when the survey was administered are not included in the study.

Definition of Terms

TBR refers to the Tennessee Board of Regents, the governing body of all public two-year colleges and the four-year colleges and universities in the state which are not included in the University of Tennessee system. It is the seventh largest public system of higher education in the United States.

ETSU refers to East Tennessee State University, a regional institution in the TBR system, located in Johnson City. Overall headcount in the fall 2004

semester was a record-setting 12,111 including students and residents in the college of medicine (Fry, 2004).

Developmental courses “are designed to assist students in developing proficiency in the basic academic competencies defined by the College Board in its EQ Project” (TBR, 1998, p. 3) and use course numbers 0800-0899.

Developmental mathematics courses taught at ETSU are elementary algebra (DSPM 0800) and intermediate algebra (DSPM 0850). In line with TBR guidelines (TBR, 2001), the basic mathematics or prealgebra course, DSPM 0700, was discontinued at ETSU beginning summer of 2002, and students whose placement scores indicated a need for this course were either advised to take the course at a community college or enrolled in 0800 with a recommendation to intensively review their arithmetic.

A core mathematics course is a course required of students pursuing a bachelor’s degree. At ETSU, unlike many other colleges and universities across the nation, the required mathematics course for most students who are not majoring in a math, science, or technical field is MATH 1530, probability and statistics (ETSU, 2004). This requirement – unlike the algebra-based course requirements of many universities – is more in line with recommendations by the National Council of Teachers of Mathematics (2000) and the American Mathematical Association of Two-Year Colleges (1995). Students majoring in technical or scientific fields must take MATH 1840, analytic geometry and differential calculus, or MATH 1910, Calculus I, instead to satisfy the

requirements for their bachelor's degree (ETSU, 2004). Students in these last two courses are not part of the present study.

The COMPASS (Computerized Adaptive Placement Assessment and Support System) test is a commercially produced program made by ACT, Inc. It is used in all TBR institutions to determine correct placement of a student in basic mathematics or elementary or intermediate algebra, or remedial or developmental levels of reading and English composition. Its predecessor for this same task was the AAPP, the Academic Assessment and Placement Program. Both included several subtests within mathematics, such as arithmetic skills, elementary algebra skills, and intermediate algebra skills. Currently the COMPASS is given only to nontraditional students. The COMPASS is now given at a computer (rather than by paper and pencil) and consists of a writing sample, a reading comprehension test, a pre-algebra test, and an algebra test. It uses adaptive questioning, so different test takers may answer different numbers of questions depending on their responses. The test is untimed, so it can easily be administered to students on a walk-in basis at the college testing center (ACT, 2003). COMPASS scores are reported on a scale from 1 to 99. Currently students taking COMPASS are recommended to take prealgebra (which is no longer offered by ETSU) if their prealgebra score is 29 or less. A student is placed in elementary algebra with a prealgebra score of 30 through 99 and an algebra score of 20-27, for intermediate algebra with an algebra score of 28-49, and

college-level mathematics classes with an algebra score of 50 or higher (Division of Developmental Studies, 2002).

Success in a developmental mathematics course will be defined as achieving a grade of A, A-, B+, B, B-, C+, or C (equivalent to a numeric average of 70% or higher) in the course. A grade of F will be considered not being successful. By TBR policy, grades of C-, D+, or D are not given in developmental studies classes (ETSU, 2004; TBR, 2003). Records with any other grade, i.e., W (withdrew), WF (withdrew failing), FN (failure due to nonattendance), or I (incomplete), will be omitted, since circumstances for receiving these grades can be varied, often due to non-academic reasons such as personal or family illness.

Success in MATH 1530, Probability and Statistics, will be defined as achieving a grade of A, A-, B+, B, B-, C+, C, C-, D+, or D. A grade of F will be considered unsuccessful. Again, grades of W, WF, I and FN will be omitted from consideration.

SIS is the common acronym used for the Student Information System computer program used at ETSU and other TBR institutions which accesses student records, class rosters, course offerings, and other academic matters. Access to SIS is limited to faculty and staff with authorization to view different screens, with access granted according to the employee's duties.

In the present study a traditional student will be defined as a student who has a valid ACT or SAT score less than three years old, and a nontraditional student will be defined as one who took the COMPASS battery due to not

having an ACT or SAT score less than three years old. This definition differs from more common ones for practical reasons. The distinction between a traditional and nontraditional student is usually made based on a student's age at matriculation, ranging somewhere between 21 and 23. Sometimes the age cutoff for differentiating between traditional and nontraditional students is higher; Meeks (1989), for example, used age 25 as a separation. Some classification schemes have also included as nontraditional students those who were married, had children, or were working full time and attending school part time. In the not-too-distant past, the cutoff for a study such as the present one would have been 21, for entering students under the age of 21 were required to submit ACT or SAT scores, but students aged 21 and older were required to take the COMPASS battery instead of the ACT or SAT. In practice, most of the students with ACT scores will be younger than 21, and those with COMPASS scores will be older.

Research Questions

The goal of this study is to see how certain variables relate to success in the course and to find regression equations to predict the grades for students enrolled in DSPM 0800, DSPM 0850, or MATH 1530 in the fall. The research is guided by several questions. Hypotheses will be formulated in Chapter 3 to assist in answering these questions, so some of the research questions below will result in as many as three hypotheses.

1. For students with ACT scores, is there a relationship between ACT mathematics scores and course grade in elementary algebra (DSPM 0800), intermediate algebra (DSPM 0850), or probability and statistics (MATH 1530)?
2. Similarly, is there a relationship between ACT reading scores and grades in DSPM 0800, DSPM 0850, or MATH 1530?
3. For students without ACT scores, is there a relationship between their intermediate algebra score on COMPASS and their grade in DSPM 0800, DSPM 0850, or MATH 1530?
4. Similarly, is there a relationship between the reading score on COMPASS and course grades in these three courses?
5. For students in the courses studied, is there a relationship between the number of college preparatory mathematics classes taken in high school and a student's grade in the course?
6. Is there a relationship between students' high school grade point averages and their course grade in any of the three ETSU courses under study?
7. For students with valid ACT scores, can separate multiple regression equations to predict final course grade in DSPM 0800, DSPM 0850, or MATH 1530 be developed using ACT composite scores, ACT math, reading and English scores, high school GPA, number of high school mathematics classes taken, age at entry, and

number of years since the last mathematics class as independent variables?

8. For students without valid ACT scores, can separate multiple regression equations to predict final course grade in DSPM 0800, DSPM 0850, or MATH 1530 be developed using COMPASS writing, reading comprehension, prealgebra and algebra scores, number of college preparatory high school mathematics classes taken, age at entry, and number of years since the last mathematics class as independent variables?

Method and Procedures

The present study will obtain data for regression from several sources. A survey administered to students in all sections of developmental mathematics (DSPM 0800 and 0850) and MATH 1530 at ETSU will ask the number of high school mathematics courses each student passed and the year in which the students took their last pre-college mathematics course, as well as obtaining permission from the students to participate in the study. The rest of the variables for each student will be obtained from SIS, beginning with the final grade in the course on a 4.0 scale from Screen 1G7. The birth date of each student will be taken from Screen 007 to determine the student's age on the first day of the semester (August 30, 2004). For traditional students, the variables taken from SIS screens A89 and 136 will be ACT composite score, ACT mathematics score, ACT English score, ACT reading score, and overall high school grade point average.

For nontraditional students, the variables taken from SIS will be COMPASS scores in writing, reading comprehension, pre-algebra, and intermediate algebra. High school GPA is not generally available on SIS for nontraditional students, and is often not available for transfer students of any age.

The student's grade at the end of the elementary algebra (DSPM 0800), intermediate algebra (DSPM 0850), or probability and statistics (MATH 1530) course will be recorded as the dependent variable. Pearson correlations will be computed between course grades and many of the independent variables as previously described in the first six research questions. A stepwise multiple regression procedure (Norusis, 2000) will then be employed to develop, if possible, appropriate prediction equations for the dependent variable. Separate equations will be developed for DSPM 0800, DSPM 0850, and MATH 1530. Since different information is collected on entering students based on age, separate equations within each course will be developed for students with and without valid ACT scores, making a possible total of six equations. Besides the fact that different information is available for younger and older students, the decision to separate traditional and nontraditional students would also follow the recommendations of Hooper (1979) and Meeks (1989), both of whom found differences in achievement between these groups.

Organization of the Study

Chapter 1 has covered the background and statement of the problem. Chapter 2 takes a look at some pertinent literature in the field, including

research done on developmental mathematics, placement, and prediction of academic success. Chapter 3 more fully describes the courses and policies related to them and outlines the methodology of the study. The results of the tests for significance and regression equations will appear in Chapter 4. The dissertation concludes with Chapter 5, which will interpret the findings and give suggestions for future research.

Chapter 2

Review of Related Literature

The current study examines whether multiple regression using readily obtainable data about students can predict student grades in developmental mathematics courses and the most prevalent core mathematics course, probability and statistics, at East Tennessee State University. A sufficiently good prediction model could conceivably help refine the process for placing entering students into an appropriate level mathematics course and otherwise help in advising students and identifying those who might need additional help. This chapter examines related literature from previous studies which assist in informing the current study and provide a background on which to build. Because developmental studies programs may not be a familiar topic to all who read this work, a brief history and background of developmental studies in general and the developmental studies program in the universities and colleges of the Tennessee Board of Regents system in particular is presented first. Following that is a review of studies concerning prediction of success in developmental mathematics courses and with placement procedures for developmental studies programs. The chapter concludes with a survey of studies on methods of predicting success for students in core mathematics courses. Because probability and statistics is rather rare as a required mathematics course for a bachelor's degree, similar studies for other core mathematics courses as

well as studies for introductory statistics courses in other disciplines are referenced.

Developmental Studies Background

Even with heroic efforts by elementary and secondary school faculty and staff, some students enroll in higher education not completely prepared for college-level courses (Salter & Noblett, 1994). Some students did not take their high school experience seriously. Others may have attended high schools which did not offer sufficient college preparatory courses, or had classes taught by teachers assigned to courses outside of their certification. Other entering college students did not plan on attending college and consequently did not take the full college preparatory curriculum in high school. A growing number of students enter college many years after finishing high school, and may have forgotten what they learned.

Having underprepared students entering college is hardly a new phenomenon, however. In its early days, the president of Vassar College complained that students' achievement fell so far below scale as to be unmeasurable (Casazza & Silverman, 1996). Henry Tappan, president of the University of Michigan, lamented in his 1852 inaugural address that colleges were teaching too many courses that belonged in secondary or elementary schools, thereby lowering the standards of the university (Maxwell, 1979). By the nineteenth century, colleges and universities began creating preparatory departments, beginning in 1849 with the University of Wisconsin (Casazza &

Silverman). Others offered tutoring or additional courses to bring students up to college level. The passage of the first and second Morrill Acts saw the emergence of land grant colleges in the late nineteenth century, bringing access to higher education to more students. Many of these students had no access to public high schools and thus needed the services of preparatory programs (Brubacher & Rudy, 1976; Casazza & Silverman).

In the early twentieth century more students attended high school and college entrance standards were tightened; even so, the majority of students entering Harvard, Yale, Princeton, and Columbia did not fully meet entrance requirements in 1907, and a U. S. Commissioner of Education report in 1915 reported 350 colleges with preparatory departments. (Maxwell, 1979). After World War II, the GI Bill of Rights paid for veterans to attend college, seeing over a million veterans entering college and bringing in money for auxiliary services – tutoring, advising, guidance, and study skills training. (Casazza, 1999). Even though the returning servicemen entered underprepared, they “systematically outperformed their younger, selectively admitted classmates, and demonstrated a model of educational success that could come with greater maturity and a second chance” (McCabe & Day, 1998, p. 3). By the 1970s, the college student population grew considerably with higher percentages of women, students of color, first-generation college students, students from poorer families, and students with learning disabilities and health issues (Casazza). The rapid rise of open-access community colleges in the 1960s and 1970s brought

even larger numbers of students seeking higher education. More underprepared students attended community colleges in the 1960s and early 1970s due to policies which increased admissions standards at four-year institutions (Boylan, 1995).

The Tennessee Board of Regents (TBR) system has had a formal system of developmental studies programs in place since 1984. Legislation and lawsuits resulted in a program for underprepared students identified by ACT and other placement test scores in math, composition, and reading. The programs also included advising, study skills courses, program evaluation, and professional development for faculty (Bader & Hardin, 2002). With a mandate from the legislature to reduce costs during a budget shortfall of several consecutive years, the TBR was required to come up with a method to “operate more efficiently and with more limited resources” (TBR, 2001, p. 1). The lowest levels of courses, called basic or remedial courses (numbered 0700), were moved to community colleges only, and all developmental courses, even those taught at universities, were funded at the community college level of funding. Placement methods changed also. Whereas formerly most traditional students took the ACT and then, if they scored poorly (i.e., less than 19 in the mathematics section), took the COMPASS or its paper-and-pencil predecessor, the ASSET (Bader & Hardin), more recent A-100 guidelines require placement into developmental mathematics with an ACT mathematics score less than 19 “or further assessment” (TBR, 2003, p. 2). The new guidelines, then, provide for students to

be placed into developmental courses based solely on an ACT subject area score, if available, or a COMPASS score. Students do have the option of requesting additional screening with payment of an additional fee (TBR, 2003). The current practice at ETSU is to allow a student to challenge developmental studies placement by taking or retaking the COMPASS exam by paying \$20 (Developmental Studies Program, 2004).

Developmental Studies Programs Today

The latest national study (Parsad & Lewis, 2003), a report of a survey by the National Center for Educational Statistics, shows that in the fall of 2000, some 22% of entering freshmen at an institution of higher education were enrolled in a developmental mathematics course (also known in the literature as remedial, basic skills, or compensatory). This percentage was unchanged from the NCES 1995 survey. At public four-year colleges and universities, 16% of entering freshmen took a developmental mathematics course compared to 17% five years earlier. Most (62%) of these students at public four-year institutions took less than a year to complete their developmental mathematics requirements, another 35% completed them in one year, and only 3% needed more than a year. These figures were similar to the ones for 1995: 69%, 28%, and 3%, respectively (Parsad & Lewis). In 2000, 78% of the 580 public four-year institutions surveyed offered at least one developmental mathematics course; this percentage was also unchanged from the 1995 NCES survey.

Developmental education is still an emerging area for formal research, so there may not be an overarching theory base that one might find in other areas, and its research borrows from other fields. The National Association for Developmental Education's definition of developmental education notes that it "is a field of practice and research within higher education with a theoretical foundation in developmental psychology and learning theory" (Higbee & Dwinell, 2000, back cover). One work regarding developmental students from a psychology professor and former developmental program director bears mentioning. Hardin (1998) identifies seven categories of undergraduate students who tend to be placed in developmental education classes. Some are "poor choosers" who did not choose a college preparatory curriculum in high school. A growing category since the late 1970s is the adult student over the age of 25 who may make up as much as two-fifths of the undergraduate population and bring needs and backgrounds which are different from their younger counterparts. Other developmental students come with a disability, whether a physical disability or a learning difference. Hardin classifies another group as "the ignored" who "had academic or physical problems that were never detected while attending high school" (p. 20) - problems such as unrecognized vision or hearing loss or undiagnosed learning disability. More students attending some colleges have limited English proficiency. Hardin labels another group as "users" - students who attend college due to "their myopic view of life" (p. 21), perhaps to get away from parents, to postpone full-time work, or to find a place

to socialize. Finally, a minority of students fall into “the extreme case” who appear qualified to attend college but have “such extreme academic, emotional, and psychological problems that they cannot be successful in higher education” (p. 22). Unfortunately, the extreme cases usually cannot be identified until they enroll and cause problems for students and faculty alike.

Predicting Course Success

Researchers have proposed a number of factors which possibly contribute to the success of students taking college mathematics courses at an introductory or lower level. Most of these factors can be broadly divided into three categories – academic, demographic, or affective. Academic factors include scores on various tests such as the SAT or ACT, various commercial or locally-produced placement tests, and grade point averages from high school. Demographic variables include sex, age, athlete status, time between high school and college mathematics classes, and race. Examples of affective variables measures of mathematics anxiety, study skills, social enrichment scores, and various measures of student attitude. Many of the researchers have examined combinations of these factors to propose a more complete model to use for improved placement or advising. The following discussion summarizes the results of several studies of both developmental and early college-level mathematics courses. Information was gleaned from journal articles, ERIC documents, and other dissertations. Some of the studies examined students in both levels of mathematics courses, and others focused on one course or even

one particular type of course. The subjects of these studies were students at community colleges and universities, public and private. Some looked at both types of institutions or multiple campuses. They ranged from as narrow as students from one Maryland county entering one college (Larson et al., 1996) to as wide as a sampling of a national study (Stribling, 1990).

Developmental Mathematics Courses

Academic variables often tend to make some contribution to a student's final course grade. In many cases, a student's high school grade point average was found to have a significant relationship with the grade on a developmental mathematics course. Autrey (1998), Wambach & del Mas (1998), Lott (1990), McFadden (1986), Thompson (1998), and Rives (1992) found this to be true for developmental mathematics courses in general. The models proposed by McLean & Williams (2003) showed high school GPA to be a significant predictor for elementary algebra grades ($p < .001$) at ETSU any time it was available. Hutson (1999) found overall high school GPA to be a significant predictor of success in intermediate algebra, but not in a fundamentals of mathematics course; likewise, the grade point average for high school mathematics courses tended to be a significant predictor for intermediate algebra but not for fundamentals of mathematics. Marwick (2002) also noted a significant predictive tendency for self-reported high school mathematics grades in developmental mathematics courses. Meeks (1989) found that high school mathematics grades can be used to predict success for traditional aged developmental mathematics

students, but not for students aged 25 or older. Long (2003), on the other hand, found no significant correlation between overall high school GPA and grade in a developmental mathematics course.

Another academic variable used by researchers was the student's score on college entrance exams such as the ACT or the SAT, depending on which test was more likely to be used at the institutions studied. Composite scores as well as scores on the mathematics section were used. Lott (1990) found the SAT mathematics score contributed significantly to predicting grades in developmental mathematics courses for students with a high school diploma, whether or not they had taken a full selection of college preparatory courses; however, such was not the case for students with a GED. McLean & Williams (2003) found ACT mathematics scores to be significant predictors of elementary algebra grades at ETSU in the fall of 2002. Larson et al. (1996) found that for Montgomery County, Maryland students entering Montgomery College, "performing well on the SAT" (p. 14) was one of the three best predictors of whether or not a student was placed into a developmental mathematics course. However, Long (2003) found no predictive ability for either the ACT composite or mathematics scores.

In addition to—or instead of—entrance exam scores, some institutions and states employ instruments designed specifically for placing students into the correct mathematics course level. These include the COMPASS, ASSET, CPT (College Placement Test), Basic Skills Exam, locally produced tests, and state

tests such as Texas' Pre-TASP Test or Florida's CLAST. Researchers have had mixed results in finding whether these tests contribute significantly to predicting success in developmental mathematics courses. McLean & Williams (2003) proposed models of predicting elementary algebra grades at ETSU in which the Algebra 2 portion of the COMPASS was a significant predictor when available (p ranging between .006 and .045 depending on other independent variables involved). Long (2003) found no predictive ability for the COMPASS mathematics, reading, or English sections for any of five developmental mathematics courses at the community college studied. Day (1997) found that the CPT was the very best predictor for elementary algebra, but its use for intermediate algebra was inconclusive. Little (2002) found a significant relationship between score on an algebra achievement test and elementary algebra grades. Preast (1998) found a strong significant relationship existed between the reading section of the Texas Academic Skills Program test and elementary algebra grades. McFadden (1986) showed a significant relationship between the Basic Skills Exam and grades in developmental mathematics.

Some students enter college a number of years after dropping out of high school and consequently may have a GED score instead of a useful high school GPA. Norman (1997) investigated whether the GED test could be used for placement purposes for those students who had recently taken the test and applied to enter a community college. The ASSET Test is the paper-and-pencil equivalent of the COMPASS test sometimes used by TBR institutions for

placement. There was only a moderate correlation between ASSET and similar parts of the GED test (ranging between .44 and .69), leading Norman to conclude that while the GED could not replace ASSET for placement purposes, it could be used as an adjunct in assisting in the placement process.

Several researchers considered a student's background in high school mathematics or mathematics GPA in anticipating grade in developmental mathematics courses. Rives (1992) and Marwick (2002) found that the number of high school mathematics courses taken made a difference. Branum (1990) found the number of semesters of algebra in high school to be significant only for elementary algebra students' course grade. Meeks (1989) determined that high school mathematics background was important only for traditional students, not for nontraditional students. High school mathematics GPA was significantly related to final developmental mathematics grades for intermediate algebra, but not fundamentals of mathematics in Hutson's (1999) study.

Finally, a few academic variables which could not be determined before the beginning of a course were identified by several researchers. College GPA and the instructor were both predictors of elementary algebra grade (Little, 2002), though Smith et al. (1996) saw no predictive value based on instructor. Attendance was found to contribute significantly to developmental mathematics course grade by both Faro-Schroeder (1995) and Smith et al. (1996). For traditional students, the results of a survey on study habits was found to be significantly related to course grade (Meeks, 1989).

In addition to academic variables, several demographic variables have been studied to see if they have any relationship to successfully completing a developmental mathematics course. One such variable is age, often in the form of reporting whether a student's age falls in the traditional or nontraditional category. Long (2003) and Smith (1996) found that age was not significantly related to end of course grade in a developmental mathematics course. Hutson (1999) did find a significant relationship for intermediate algebra students, but not for students in a fundamentals of mathematics class. Rives (1992) noted a significant relationship between the length of time since the last mathematics course and grade in developmental mathematics.

Gender of students has also been studied with mixed results for whether it affected successful completion of developmental mathematics courses. Some researchers (Branum, 1990; Little, 2002) did find that grades were significantly different between the sexes. Others (Lawrence, 1988; Long, 2003; Smith et al., 1996) saw no such significant difference. Lott (1990) discovered differences in success between the sexes for students who completed high school with or without a college preparatory curriculum, but not for those who had a GED instead.

Another demographic variable that a few researchers have included in their studies was that of race. Race was significant in the findings of Lott (1990) and Little (2002). Only being black was a distinguishing racial difference in the

studies of Autrey (1998) and Faro-Schroeder (1995). Lawrence (1988) and McFadden (1986) saw no racial differences in their studies.

Affective variables have also been examined to find whether they have a significant impact on developmental mathematics course success rates. Because the present study does not deal with affective variables, only a cursory look at this area is provided here. Much more information is available in the literature. Smith et al. (1996) did not see a significant grade difference based on anxiety levels, but Little (2002) did see a relationship between mathematics attitude and elementary algebra grade. Autrey (1998) found relationships between developmental mathematics success and the results of the College Student Inventory along with another variable known as the social enrichment score. Smith et al. also deduced in their qualitative study that students' perception of their success and their engagement in class were also important qualities that contributed towards completing developmental mathematics courses. Those who were attentive during class even infrequently were about five times more likely to pass the class than those who were not. Teacher-student interaction and student note-taking behavior did not seem to make as large an impact.

Core College Mathematics Courses

In contrast to developmental mathematics courses, very little information seems to exist in the literature concerning ways of predicting a student's grade in an introductory freshman level probability and statistics course. In fact, only one fairly recent study (Yablonsky, 1989) could be found which dealt with predictor

variables for success in an elementary statistics class. No doubt this is due in part to the fact that very few universities yet require probability and statistics as a core mathematics course for graduation. In the Tennessee Board of Regents System, for example, MATH 1530 (probability and statistics) is not even listed as an option for the required three hours of mathematics for two of the six universities (Tennessee State and the University of Memphis), and only ETSU requires MATH 1530 for the vast majority of its undergraduate students. There are, however, studies in the literature pertaining to predicting grades of students in other freshman-level mathematics courses, as well as a few studies dealing with introductory statistics courses in other disciplines such as psychology. Such studies are included in this chapter because they still deal with freshman or entry-level mathematics courses and thus might shed light on characteristics of successful students in an introductory probability and statistics class.

Academic variables have also been found to have significant relationships with successful completion of core college mathematics courses for students. Composite or total scores in the ACT or SAT as well as the mathematics section scores are often seen as predictive variables. The ACT composite score was significant for precalculus students in Carmichael's (1986) study of black students at one university, but not as much for calculus students. The ACT mathematics score was found to be a significant predictor for black students taking a course called college mathematics (Jackson-Teal, 1990), for college algebra students (Osborn, 2002), and for an assortment of entry-level

mathematics courses (Blansett, 1988). Yablonsky (1989) found the both the mathematics and reading portions of the SAT to be a significant predictor for elementary statistics course grade. Models generated for college algebra by K. Johnson (1996), however, did not find ACT or SAT mathematics subscores or ACT composite or SAT total scores to be among the best predictors of college algebra grades.

Other college entrance or placement examinations were also found to have a significant predictive effect. Darbro (2002) found the COMPASS to be a good predictor for grades in the course known as college mathematics. Garcia (1998) found this to be true for the COMPASS and TASP in college algebra. Likewise, Preast (1998) found Texas' TASP mathematics and reading sections to be significantly related to college algebra course grades. Local pretests were significant success predictors for entry-level mathematics courses (Blansett, 1988), college algebra (Armstrong, 1999), and college math (Marwick, 2002).

As with the developmental mathematics courses, high school background was often found to be significantly related to course greater success in college-level mathematics courses. Garcia (1998), Hutson (1999), and K. Johnson (1996) all found this to be true for college algebra with high school GPA. Lawrence (1988) found such a relationship for in an algebra and trigonometry course. Carmichael (1986) found high school GPA a good predictor for students taking calculus, but not precalculus. Jackson-Teal (1990) found a significant relationship between high school mathematics GPA and the course grade in the class known

as college mathematics. Hutson did not find that high school mathematics GPA was significantly related to grade in college algebra, even though overall high school GPA was. K. Johnson saw a significant relationship between final high school percentile rank and college algebra grade.

The number or difficulty of high school mathematics courses taken was also seen to be a significant predictor for females taking college algebra (Hutson, 1999) but not for males. For all students studied it helped explain success in college mathematics (Jackson-Teal, 1990), college algebra and calculus (Rives, 1992), and elementary statistics (Yablonsky, 1989). Burns (1990) saw that college algebra students who took a mathematics course their senior year in high school scored significantly higher than those who did not. Wheat (1990) found that college algebra students who took a trigonometry and elementary analysis class in high school did better than those who did not.

In a few studies, some independent variables related other scholastic activity in college to success in various mathematics courses. Undergraduate GPA had a relationship with grade in a graduate introductory statistics course for majors in other fields in R. Johnson's (1996) study. Sigler (2002) found that first-quarter college GPA related significantly to success in college algebra. Yablonsky (1989) found a significant relationship between grades in finite mathematics and elementary statistics. Students in Armstrong's (1999) study who did not take intermediate algebra did significantly better in college algebra than those who did.

Demographic variables were also examined for some college-level mathematics courses. Although age seemed to play no significant part in predicting college algebra grades for Hutson (1999), it did make a difference in Wheat's (1990) study of college algebra students and in the general education mathematics courses studied by Zankofski (1999). The length of time since the last mathematics course made a significant impact in students taking college algebra or calculus in Rives' (1992) study. Relating gender to success in core-level mathematics courses had mixed results. Burns (1990), Armstrong (1999), and Wheat all saw a grade difference based on gender in college algebra, as did Zankofski in general education mathematics courses. No such differences by sex were found, though, by Carmichael (1986) in precalculus or calculus, Jackson-Teal (1990) in college mathematics, Lawrence (1988) in algebra and trigonometry, or by Blansett (1988) in entry-level courses. Racial groups did not seem to differ in success in algebra and trigonometry (Lawrence) or entry-level mathematics (Blansett), but did seem to have some impact on grades in unspecified general education mathematics courses (Zankofski).

Researchers sometimes analyzed some less common demographic variables with varying results. Among those with a significant impact on grades in a general education mathematics were U. S. citizenship status, enrollment status (full vs. part time), instructor, and class meeting time (Zankofski, 1999). On the other hand, whether a student resided on campus or was involved in

campus organizations did not seem to be a significant predictor of success in entry level mathematics (Blansett, 1988).

In the works sampled for this literature review, only a few studies predicting grades in core college mathematics classes included affective variables, though there are certainly many other studies which only deal with affective variables – math anxiety and test anxiety come to mind immediately. R. Johnson (1996) found both attitude and learning styles and strategies to be positively correlated with success in an graduate statistics course for non-mathematics majors. Scott (2001) saw a positive relationship between an undergraduate statistics course grade and the score found on the Survey of Attitudes Towards Statistics, or SATS. Wheat (1990) was able to relate a measure of a student's self-concept with grade in college algebra.

Summary

For nearly four centuries Americans have been going to college, and for that same amount of time, some students have arrived underprepared for the work expected of them. Today the vast majority of colleges – public and private, four-year and two-year – offer some sort of remedial or developmental programs for underprepared students, especially in mathematics. Overall, between one fifth and one fourth of first-time freshmen must take a mathematics course that is below college level – more at two-year than four and public than private.

At least several dozen studies in the last two decades have looked at factors which contribute to success in developmental or core college mathematics courses. Most of these studies looked at multiple factors for each course studied. Various academic, demographic, and affective independent variables have been shown to have a significant relationship with course grade or success in the mathematics course studied. For nearly every variable that was found to be related to such success, there is at least one study that found no relationship. The next chapter will describe the population studied, the structure of the courses these students took, the instruments used, and the statistical methods employed to investigate the relationships among the variables studied.

Chapter 3

Methodology

The present study examines data about incoming students in three mathematics courses at ETSU to see if it is possible to predict their course grade from data that can be obtained about the students before the semester begins. This chapter begins with a description of the courses under study. Next is a description of the instrumentation used. The chapter concludes with a discussion of the statistical methods used in this study.

The Courses

Students in three mathematics courses at ETSU are the subjects of this study. The first two courses, DSPM 0800 (elementary algebra) and DSPM 0850 (intermediate algebra), are developmental courses. Both carry three hours of credit, but the credit does not count towards graduation for any degree. The third, MATH 1530 (probability and statistics), is a three-hour mathematics course that forms part of the core undergraduate curriculum and is the required mathematics course for most students who are not majoring in a scientific or technical field.

The two developmental courses follow a curriculum that was designed by a committee of instructors from the various universities and community colleges of the Tennessee Board of Regents system. All sections of these courses are taught by either full-time faculty who were hired especially to teach

developmental mathematics or by adjunct faculty with master's degrees, all of whom have taught the courses before. In fact, most of the adjunct faculty have taught the courses at ETSU for many years; some are also present or former high school mathematics teachers. Individual instructors have considerable latitude in the way they teach the courses and make and grade their own tests, but there is a common set of objectives for each course accompanied by a list of which sections of the textbook are to be covered. The list of objectives was drawn up by a committee of developmental mathematics instructors from across the TBR system in 2002. There is a common departmental final exam for both elementary and intermediate algebra which consists of 33 multiple-choice questions agreed upon by the faculty. The course average, rounded to the nearest whole number, is converted to a letter grade using the scale shown in [Table 1](#).

Table 1
Grading Scale Used in DSPM 0800 and 0850

Average	Letter Grade	Grade Points
90-100	A	4
87-89	A-	3.7
84-86	B+	3.3
80-83	B	3
77-79	B-	2.7
74-76	C+	2.3
70-73	C	2
0 - 70	F	0

Tennessee Board of Regents guideline A-100 (TBR, 2003) prohibits assigning a passing grade lower than C in developmental courses, so grades of C-, D+, and D found in other courses are not given for a DSPM class. As with all courses at ETSU, the instructor records a grade of FN (failure due to nonattendance) for students who stop attending class and receive a failing grade, though the grade shows up as a simple F on the official transcript.

One section each of DSPM 0800 and 0850 were taught by live interactive television using the same textbooks, final exams, and other criteria as the other sections. These sections of developmental mathematics are included in the study because previous research (Hodge-Hardin, 1995) shows no significant difference in achievement between interactive television and regular classroom settings for these two courses.

Calculator usage is allowed at all times in both DSPM courses, although a specific calculator is not required. Many colleges now require a graphing calculator for their developmental mathematics courses, but because most ETSU students take probability and statistics—which does not require a graphing calculator—the developmental math faculty feel that asking students to spend the additional \$100 for a calculator beyond the cost of the book, also over \$100, is excessive.

The textbook used in both the developmental mathematics courses is *Beginning & Intermediate Algebra* by K. Elayn Martin-Gay, published by Prentice-Hall. In the fall semester of 2004, a new edition of the book was being phased in.

The DSPM 0800 classes used the new third edition (Martin-Gay, 2004), and the DSPM 0850 classes used the second edition (Martin-Gay, 2001) so that students who had taken the 0800 course in the spring or summer of 2004 and already had the second edition of the textbook would not need to buy another text. Students also had the option to purchase a student solutions manual and study guide which accompanied the textbooks. Some instructors also made additional study materials available on a web-based system known as Blackboard.

In the elementary algebra course (DSPM 0800), students review operations with integers, then study linear equations and inequalities in one or two variables. In the intermediate algebra course (DSPM 0850), the main topics are properties of exponents, factoring polynomials, rational expressions, proportions, radical expressions, and quadratic equations. Students learn to simplify expressions and solve equations in each of those chapters.

The probability and statistics course, MATH 1530, satisfies the mathematics requirement for most undergraduate degrees at ETSU. The course is taught from a common syllabus by full-time faculty members, adjunct faculty, and graduate students. Instructors of the course meet together at least once a month to compare notes and make decisions. Most sections of the course – with the exception of the online, large lecture, and interactive television sections – meet in the same rooms twice a week (Monday/Wednesday or Tuesday/Thursday). One day each week is spent in a classroom informally known as the “stat mansion” and the other day is spent in a computer laboratory

across the hall commonly referred to as the “stat cave,” often with a graduate student present to help. The “stat cave,” a computer laboratory which was funded by a National Science Foundation grant, is also open for student use on Fridays with a graduate student onsite. Students use software and applets to reinforce concepts learned in class and to work with data. Most sections use Minitab with a few sections using SPSS or SAS. One section is taught as an online class, another is taught as a large lecture class, and nine sections (three different time slots) are taught by interactive television (two-way audio and two-way video) with simultaneous sections at campuses in Johnson City, Kingsport, and Bristol. The online, large lecture, and television classes do not meet together in a computer laboratory. A web page (Seier, 2004) is set up to provide additional resources to students in all sections of MATH 1530. For all sections of the course, a common final exam was given at various locations simultaneously on the afternoon of Saturday, December 11. A common 1000-point grading scale is used for all sections of MATH 1530. The final exam counts for 300 points, computer-based homework counts for 100 points, and the other 600 points are up to the individual instructor, and include regular tests, additional homework, quizzes, projects, etc. Students may earn as many as 60 additional points for perfect or near-perfect attendance. The scale used to determine the grade for the course is seen in [Table 2](#).

Table 2
Grading Scale Used in MATH 1530

Total Points	Letter Grade	Grade Points
950 - 1000	A	4.0
900 - 949	A-	3.7
880 - 899	B+	3.3
820 - 879	B	3.0
800 - 819	B-	2.7
780 - 799	C+	2.3
720 - 779	C	2.0
700 - 719	C-	1.7
650 - 699	D+	1.3
600 - 649	D	1.0
< 600	F	0.0

Instrumentation: ACT and COMPASS

Currently, entering students are placed into DSPM 0800, DSPM 0850, or MATH 1530 based on one of two criteria. Students who have ACT scores less than three years old – typically recent high school graduates – are placed based on their mathematics scores. An ACT mathematics score of 17 or less (or an SAT mathematics score of 440 or less) initially places a student into DSPM 0800. A student whose ACT mathematics score is 18 (or SAT of 450) begins with DSPM 0850. A student with an ACT mathematics score of 19 or greater (SAT greater than 450) takes no developmental mathematics course and begins with a college-

level course, which for most students will be probability and statistics, MATH 1530. A student with an ACT score less than 19 may choose to pay to take the COMPASS exam to challenge placement into developmental mathematics, and is then bound by the result of the latter assessment. Students majoring in a science or technology area take at least one semester of regular or technical calculus (and precalculus if necessary), but those students are not part of this study.

Students who have no recent ACT scores (three years old or less) are placed into an appropriate developmental or college-level courses based on their scores on the COMPASS, which students take at a computer in the university's testing center prior to the beginning of the semester. The COMPASS consists of several test parts, including a prealgebra test and an algebra test. The scores on each test range from 1 to 99 (ACT, 2003). Currently students taking COMPASS are recommended to take prealgebra if their prealgebra score on the test is 29 or less. Prealgebra (DSPM 0700) is no longer taught by ETSU faculty. Instead, the course is taught on campus through an arrangement with Northeast State Community College. Only two sections with a total of 25 students were offered this way in the fall of 2004, so this course was not included in the present study. A student is placed in elementary algebra with a prealgebra score of 30 through 99 and an algebra score of 20-27, for intermediate algebra with an algebra score of 28-49, and college-level mathematics classes with an algebra score of 50 or higher (Division of Developmental Studies, 2002).

The COMPASS test is an untimed instrument taken by the student at a computer in a testing center which is designed to measure a student's preparedness in reading, writing, mathematics, and English as a second language. The mathematics portion of the test can measure numerical skills/pre-algebra, algebra, college algebra, trigonometry, and geometry, but only the pre-algebra and algebra sections are used at ETSU. The test is computer adaptive, meaning that students do not receive a prescribed set of exactly the same types of questions. Rather, the test aims to produce a proficiency estimation (ACT, 2003). Each test has a pool of sets of items along with an algorithm for determining how many correct items indicate mastery and what kinds of questions to ask next. The test software is also programmed with "a method for estimating the level of performance for each examinee [and] a procedure for determining when to stop administering test items" (ACT, 2003, p. 130). At some point, the test determines when it either has enough information to calculate a score or reaches a maximum number of questions given, and then ends the test. Consequently, no two students will have exactly the same test, and different students taking the same test will be given different numbers of questions. However, a method known as "item calibration" for various question pools is employed to assure that results of tests taken by different students are comparable.

The ACT assessment is a nationally-normed test comprised of multiple-choice tests covering four academic areas- English, reading, mathematics, and

science reasoning. It is typically given to high school seniors and is used by some states, including Tennessee, for decisions on admitting a student to a college or university. Items on the test are based on content usually found in state curriculum frameworks and textbooks at the secondary level, and are picked to represent content that college faculty members felt were important to be successful in entry-level courses at a college or university. A 1995 rescaling of the test allowed it to work not only as an admissions test, but also a placement test to determine whether a student is ready for freshman level courses (ACT, 1997). In the mathematics section, content includes pre-algebra, elementary algebra, intermediate algebra, coordinate geometry, plane geometry, and trigonometry; calculator usage is allowed. Scores on the composite and individual sections of the ACT range from one to 36, with a standard error of measurement of “two scale score units for each of the subject-area test scores and one scale score unit for the Composite” (ACT, 1997, p. 19). Median reliability statistics for individual scale scores from 1995-96 were 0.91 for English, 0.91 for mathematics, 0.86 for reading, 0.84 for science reasoning, and 0.96 for the composite score (p.23). Optimal cutoff scores for success in college-level courses are suggested by ACT based on “logistic regression models about the to calculate estimated probabilities of success... predicted from the relevant ACT assessment score; success was defined as receiving a B or higher grade in the course” (p. 71). The most accurate cut off score was found to be the one in which the probability of a student’s success is 0.5. However, it should be noted that the

cutoff scores suggested by ACT for placement into college level courses are higher than the ones that are actually used by the TBR system.

All mathematics placement in TBR institutions is mandatory; that is, a student may not opt out of a developmental mathematics course, nor can a student opt into a developmental course if not placed into one. Numerous studies show that mandatory placement into developmental classes when deemed necessary is associated with improved college grade point averages and increased retention rate – provided the instrument or procedure used was valid and a quality advisement system was in place (Akst and Hirsch, 1991).

Data Collection

During the early part of the fall semester of 2004, a survey was administered to all students enrolled in DSPM 0800, DSPM 0850, and MATH 1530. The survey asked for three pieces of information: a student's name, a list of mathematics classes taken and passed in high school, and the last year that the student had taken a high school mathematics class. The survey is shown in Appendix A and the consent document is in Appendix B. On the survey, a number of students wrote "junior" or "senior" instead of the calendar year. In those cases, the year of high school graduation was obtained from SIS Screen A89. If the student indicated the senior year, then the assumption was made that the student's last mathematics course continued into the spring semester of the senior year. Likewise, the response of "junior year" was interpreted as being

one year before high school graduation. Data collected from the surveys was transferred to a spreadsheet pre-loaded with the class rolls from SIS.

From SIS, the following independent variables were added whenever available: ACT scores (composite, and subscores in mathematics, reading, and writing), COMPASS scores (prealgebra, algebra, and reading), student's birth date, and high school grade point average. In the event that a student had multiple ACT or COMPASS scores, the highest score was used, reflecting the standard employed by the university in determining course placement. SIS is programmed to automatically convert SAT scores to their ACT equivalent for a composite, mathematics, reading, and writing score. The resulting highest ACT/SAT score is labeled as a "DSPP score."

After the end of the semester, each student's grade in DSPM 0800 or 0850 or MATH 1530 was added to the spreadsheet as the dependent variable. Grades of W (withdrew), WF (withdrew failing), and I (incomplete) were also loaded in the spreadsheet but not included in any of the models developed. To make results of this study consistent with other studies of student grades carried out at the university (e.g. McLean & Williams, 2003), a grade recorded as FN (failure due to nonattendance) was considered in the same category as W and WF.

A total of 304 students were enrolled in elementary algebra during the Fall, 2004, semester. Of those, 149 (or 49%) returned surveys. There were five sections in which the instructor forgot to give the surveys or the surveys did not reach the off-campus site, accounting for 62 students. All daytime sections were

represented; the surveys not returned were in the night, off-campus, and interactive television sections. One other section of this course was taught through the Regents Online Degree Program (RODP), but was not considered because it was web-based, included students from all over the TBR system, and was taught by an instructor from another institution.

Out of the 455 students enrolled in intermediate algebra in the fall semester of 2004, surveys were completed by 214 students, or 47% of the students enrolled. (One additional survey was completed without a name, making it unusable.) In three daytime sections the instructors forgot to administer the surveys, accounting for 127 students. The night section, the Kingsport section, and the interactive television sections were all included. A web-based RODP section was neither included nor tallied in this study.

There were 1074 students who took MATH 1530 in the fall semester of 2004, and 631 (or 58.8%) of those students completed the survey. Four sections (with a total of 155 students) did not receive surveys because the instructors reported that they forgot to give them. One other section (with 21 students) was not surveyed because it was a web-only ETSU section, making administering the survey and obtaining signatures problematic. Similarly, the RODP section of this course was not included in the survey or in any tallies listed for the same reasons listed above for their not being included in the other courses.

Statistical Methods Used

For the first six research questions, a correlation coefficient was obtained. A correlation coefficient (r) ranges in value from -1 to +1, with $r = -1$ indicating that when the value of one variable increases, the other always decreases. A correlation coefficient of +1 means that the two variables always increase or decrease together, and a correlation coefficient of 0 means that there is no discernible linear relationship between the two variables.

For the last two research questions, the method of stepwise multiple regression was used. Multiple regression is used to determine the strength of the relation of several independent variables to a dependent variable (Norušis, 2000). An independent variable is put into an equation if it meets the criteria for significance (.05 in this case). Other independent variables are added one at a time, and if they add to the significance level of the equation, they are retained; if they do not, they are removed. The process continues until all variables have been examined.

All data in this study were compiled into a Microsoft Excel spreadsheet. Ages as of August 30, 2004, the first day of classes, were calculated using a formula in Excel. The spreadsheet was then loaded into SPSS for Windows to perform all other computations needed to answer the research questions posed.

Summary

To conduct this study, a survey was given to students enrolled in DSPM 0800 and 0850 and MATH 1530 sections in the fall of 2004. The survey asked the students to list the mathematics courses they had passed in high school and tell when the last of those courses was taken. A search of computerized student records yielded the independent variables (if available) of age as of the first day of class, scores on sections of the ACT as well as the composite score, scores on sections of COMPASS, and high school grade point average along with the dependent variable of end-of-course grade. Correlations were computed between course grade and several independent variables, and multiple regression equations were developed to see whether a combination of several of the independent variables could predict the student's grade. The next chapter presents the results of these tests.

Chapter 4

Results

The purpose of this study was to determine whether any kind of relationship could be found between a student's end of semester grade in elementary algebra, intermediate algebra, or probability and statistics on the one hand and a number of easily obtainable variables such as placement scores, high school grade point average, and the number of high school mathematics courses taken on the other. In addition, for each course a goal was to determine whether a regression equation could be developed to see if a combination of these variables could be used to better predict a student's grade. The previous chapter described the methods that were used to obtain this information. This chapter reports the findings of the study.

[Table 3](#) shows the distribution of grades in all three courses for students who completed the survey. Mean course grade for the 149 surveyed students in elementary algebra was 2.785, with a standard deviation of 1.2593. The 214 students in intermediate algebra who responded to the survey received a mean course grade of 2.991, with a standard deviation of 1.2075. The mean course grade for the 631 students surveyed from probability and statistics was 2.419, with a standard deviation of 1.1526. As noted earlier, grades of FN, I, W, and WF were not used in the statistics from the research questions.

Table 3
End of Semester Course Grades for Students Surveyed

Grade	DSPM 0800	DSPM 0850	MATH 1530
A	35	75	70
A-	17	18	48
B+	14	17	35
B	21	21	98
B-	8	11	36
C+	9	13	34
C	13	25	89
C-	*	*	35
D+	*	*	42
D	*	*	28
F	19	19	49
FN**	10	8	58
I**	0	1	1
W**	3	6	5
WF**	0	0	3
Total	149	214	631
Mean Grade Points	2.785	2.991	2.419
Standard Deviation	1.2993	1.2075	1.1526

* Grades of C-, D+, and D are not allowed in developmental studies courses.

**Not used in answering the research questions.

Results of Research Questions

The remainder of this chapter presents results obtained from analysis of the research questions posed in Chapter 1. In each case, the research question is followed by the results for each of the three courses studied – elementary algebra (DSPM 0800), intermediate algebra (DSPM 0850), and probability and statistics (MATH 1530).

Research Question 1. For students with ACT scores, is there a relationship between ACT mathematics scores and course grade in elementary algebra (DSPM 0800), intermediate algebra, or probability and statistics (MATH 1530)?

[Table 4](#) shows the statistics for this research question for elementary algebra, intermediate algebra, and probability and statistics, respectively. In DSPM 0800, the Pearson correlation coefficient is .025, $p = .802$. This indicates that no significant correlation could be found between the grade a student made in elementary algebra and the student's ACT score in mathematics (or DSPP equivalent), and the null hypothesis that there is no correlation between

Table 4
Pearson Correlations between ACT Mathematics Score (ACTM) and Grade (GPTS)

		ACT Math		
		DSPM 0800	DSPM 0850	MATH 1530
GPTS	r	.025	.322**	.481**
	p	.802	.000	.000
	N	102	169	499

** $p < .01$

elementary algebra grade and ACT mathematics score must be retained. For DSPM 0850, however, the Pearson correlation coefficient is .322, $p < .001$, indicating that a significant relationship exists between a student's mathematics score on the ACT and grade in intermediate algebra, so the null hypothesis in this case must be rejected. The Pearson correlation coefficient for probability and statistics is 0.481, $p < .001$, again indicating a significant relationship between a student's ACT mathematics score and grade in MATH 1530.

Research Question 2. Is there a relationship between ACT reading scores and grades in DSPM 0800, DSPM 0850, or MATH 1530?

[Table 5](#) presents the Pearson correlation coefficients which compare grade in the course taken and score on the reading portion of the ACT assessment. As with the math portion of the ACT, there appears to be no significant correlation between the ACT reading score and course grade for students in elementary algebra ($r = .047$, $p = .642$). For students in intermediate algebra, however, there is a correlation coefficient of .164, which is significant at the .05 level ($p = .033$). In probability and statistics, the relationship is even stronger: the correlation coefficient is .338, which has a significance at the .01 level ($p < .001$). Thus for students in DSPM 0850 or MATH 1530, higher ACT reading scores are tied to higher course grades.

Table 5

Pearson Correlations between ACT Reading Scores and Course Grade

		ACT Reading		
		DSPM 0800	DSPM 0850	MATH 1530
GPTS	<i>r</i>	.047	.164*	.338**
	<i>p</i>	.642	.033	.000
	<i>N</i>	102	169	497

* $p < .05$

** $p < .01$

Research Question 3. For students without ACT scores, is there a relationship between their intermediate algebra score on COMPASS and their grade in DSPM 0800, DSPM 0850, or MATH 1530?

Pearson correlation coefficients are shown in [Table 6](#). No significant correlation was found between scores on the intermediate algebra portion of the COMPASS test and grade in elementary algebra ($r = .107, p = .448$). The only significant correlation ($r = .326, p = .029$) was found between COMPASS intermediate algebra score and grade in elementary algebra class. No correlation was found for probability and statistics grade and COMPASS intermediate algebra score ($r = .133, p = .348$). Because the COMPASS test is mostly taken by adult students, the sample sizes for each course were fairly low (52, 45, and 52, respectively), perhaps affecting the results.

Research Question 4. Is there a relationship between the reading score on COMPASS and course grades in these three courses?

Even fewer students had scores for the COMPASS reading test (36, 25, and 33 for 0800, 0850, and 1530, respectively). The results are summarized in

Table 6

Pearson Correlation between COMPASS Intermediate Algebra Scores (COMI) and Course Grade (GPTS)

		COMPASS Intermediate Algebra Score		
		DSPM 0800	DSPM 0850	MATH 1530
GPTS	<i>r</i>	.107	.326*	.133
	<i>p</i>	.448	.029	.348
	<i>N</i>	52	45	52

* $p < .05$

[Table 7](#). For students taking elementary algebra with COMPASS reading scores, there was no significant correlation ($r = .222, p = .194$) between the two values. Scores of students in intermediate algebra also showed no significant correlations between reading and intermediate algebra scores ($r = .206, p = .323$). Likewise, no significant correlation could be found for students in probability and statistics ($r = .118, p = .513$).

Research Question 5. For students in the courses studied, is there a relationship between the number of college preparatory mathematics classes taken in high school and a student's grade in the course?

The survey given to students asked for a list of the courses that students had taken and passed in high school. [Table 8](#) tallies all the different courses that students listed in their surveys. The most common courses taken by students from all three courses were Algebra 1, Algebra 2, and geometry. Almost 83% of students in elementary algebra took Algebra 1 in high school, as did 85% of intermediate algebra and nearly 83% of probability and statistics students. The

Table 7
Pearson Correlation between COMPASS Reading Scores (COMR) and Course
Grade (GPTS)

		COMPASS Reading Score		
		DSPM 0800	DSPM 0850	MATH 1530
GPTS	<i>r</i>	.222	.206	.118
	<i>p</i>	.194	.323	.513
	<i>N</i>	36	25	33

Table 8
High School Mathematics Courses Taken by Students Who Answered Survey

Course	0800	0850	1530	Course	0800	0850	1530
GED Math*	5	5	7	College Algebra	0	0	7
Arithmetic*	1	0	1	College Math	1	0	1
Basic Math*	3	2	5	Business Math	1	0	0
General Math*	8	2	7	Applied Math	1	0	1
Transition Math*	0	0	1	Applied Math 2	0	0	1
Transition Math 2*	0	0	1	Mathematics of	0	1	0
Prealgebra*	47	37	67	Money			
Prealgebra 2*	0	0	2	Advanced Algebra	0	4	1
Foundations 1*	6	1	3	Introduction to	0	1	0
Foundations 2*	16	26	28	Geometry			
Consumer Math*	1	3	5	Informal Geometry	0	1	1
Algebra 1	123	181	518	Beginning Math*	0	1	0
Algebra 2	111	182	556	Introduction to	0	1	1
Geometry	102	176	544	Algebra 2			
Geometry 2	0	0	2	Unknown	0	2	0
Precalculus	6	27	211	Business Math	0	1	1
Trigonometry with	4	27	133	O-Level British	0	0	1
Advanced Algebra				Math Course			
Calculus	2	4	88	Computer Math	0	0	3
Calculus 2	0	0	6	Integrated Math 1	0	0	3
Probability and	4	6	72	Integrated Math 2	0	0	2
Statistics				Integrated Math 3	0	0	2
Algebra 3	1	3	13	College	0	0	1
Algebra 4	0	1	0	Preparatory Math			
Intermediate	0	2	17	Fractals	0	0	1
Algebra				Basic Algebra*	0	0	1
Algebra 1a or	2	2	6	ACT/SAT	0	0	2
Algebra 1 Part 1				Preparation			
Algebra 1b or	2	3	6	Math Concepts	0	0	1
Algebra 1 Part 2				Developmental	0	0	1
Algebra A	4	5	17	Math			
Algebra B	4	6	19	Math Analysis	0	0	3
Algebra C	1	3	18	Geometry 2	0	0	2
Mathematics 1	0	1	3	Math in Society	0	0	1
Mathematics 2	0	0	3	Fundamentals of	0	0	1
Mathematics 3	0	0	1	Algebra*			
Mathematics 4	0	1	0	British Forms 1-4	0	0	1
Advanced Math	0	1	17	Saxon 2	0	0	1
Advanced Math 2	0	0	2	International	0	0	1
Discrete	0	1	2	Baccalaureate			
Mathematics				Senior Math	0	0	1
Technical Math	4	0	4				
Technical Math 2	0	0	1	Total Number of	149	214	633
				Surveys			

*Not counted as a college preparatory course.

overwhelming majority of students in all three courses also took Algebra 2 and geometry, and these figures would increase if other courses such as Algebra 1A and 1B and Math I were added. A very tiny minority of students enrolled in DSPM 0800 had taken precalculus, trigonometry, or other advanced mathematics courses in high school, compared to about an eighth of DSPM 0850 students who took precalculus or trigonometry and over a third of MATH 1530 students. (Some students listed both precalculus and trigonometry as separate courses; most listed one or the other.) A larger percentage of students in DSPM 0800 took courses below the level of high school Algebra I (e.g. prealgebra, transition mathematics, GED courses, or no mathematics at all) than in the other two courses. Nine students in 1530 also listed that they had taken physics, but that course was not counted in this study as a mathematics course. Several students checked off that they did not attend high school and proceeded to list one or more high school mathematics courses taken, so the blank on the survey about not attending high school was ignored.

The correlations between course grade and the number of college preparatory math classes taken in high school are given in [Table 9](#). Elementary algebra students took on average 2.52 college preparatory courses in high school, compared with 3.11 for intermediate algebra students and 3.73 courses by probability and statistics students. The final grade in elementary algebra seems not to be affected by the number of college preparatory courses students took in high school; the correlation is almost 0 ($r = -.068$, $p = .434$). A definite,

Table 9
Pearson Correlation between Course Grade (GPTS) and Number of College Preparatory Mathematics Taken (HSMATH)

		HSMATH		
		DSPM 0800	DSPM 0850	MATH 1530
All students				
GPTS	<i>r</i>	-.068	.191**	.265**
	<i>p</i>	.434	.007	.000
	<i>N</i>	135	198	564
	Mean number taken	2.52	3.11	3.73
	SD taken	1.034	.955	1.115
Students with ACT scores				
	<i>r</i>	-.237*	.193*	.298**
	<i>p</i>	.017	.012	.000
	<i>N</i>	102	168	499
	Mean number taken	2.84	3.28	3.85
	SD taken	1.2333	1.2000	1.034
Students with COMPASS scores				
	<i>r</i>	-.061	.131	.171
	<i>p</i>	.671	.392	.226
	<i>N</i>	51	45	52
	Mean number taken	1.88	2.53	2.85
	SD taken	1.103	1.254	1.036

Note. Total *N* for groups with ACT and COMPASS scores does not equal *N* for the entire group because some students have both scores.

**p* < .05

***p* < .01

though small, positive correlation exists for the other two courses. For DSPM 0850, a significant correlation is seen ($r = .191, p = .007$). A slightly stronger positive correlation ($r = .265$) appears for MATH 1530 ($p < .001$).

Some slightly different relationships appear when considering students who took the ACT or the COMPASS test. For students with ACT scores, there was a statistically significant correlation between course grade and the number of college preparatory math courses taken in high school for all three courses studied. Surprisingly, that correlation is negative in the case of elementary algebra ($r = -.237, p = .017$), but positive in the case of intermediate algebra ($r = .193, p = .012$) and probability and statistics ($r = .298, p < .001$), though in no case is the correlation exceptionally large. It is also worth noting that as the difficulty level of the course increases, the average number of college-preparatory mathematics courses taken in high school increases and the standard deviation decreases.

For students with COMPASS intermediate algebra scores, no significant correlations were found between the number of high school college preparatory mathematics courses taken and the grade in the current course. Once again, the mean number of courses taken in high school increases for students in higher college courses. Further analysis using the total number of high school mathematics courses taken including courses such as prealgebra or consumer mathematics might yield different results than the ones shown here.

Research Question 6. Is there a relationship between students' high school grade point averages and their course grade in any of the three ETSU courses under study?

High school grade-point averages were available only for students who had been out of high school within approximately the last five years. If students had transferred from other institutions, grade-point averages were not always reported on SIS. For many younger native (non-transfer) students, two high school averages were available – an overall average and a core average (average of the courses such as algebra, laboratory science, English, social sciences, and so forth required for college admission). Because more students had overall high school averages than core course averages, the overall high school GPA was used to answer this question. [Table 10](#) shows the Pearson correlations between overall high school GPA (HSOGPA) and course grade (GPTS).

At least for the students in the study, high school grade point average seems to be a good predictor for all three courses. For each course studied, there was a significant correlation ($p < .001$) between overall high school grade-point

Table 10
Pearson Correlation between Overall High School GPA (HSOGPA) and Course Grade (GPTS)

		HSOGPA		
		DSPM 0800	DSPM 0850	MATH 1530
GPTS	<i>r</i>	.389**	.333**	.445**
	<i>p</i>	.000	.000	.000
	<i>N</i>	105	176	500

**Significant at the .01 level. (Note: $p < .001$ in all three courses.)

average and grade in the course taken. The value for r was .389 for elementary algebra, .333 for intermediate algebra, and .445 in probability and statistics.

Though statistically significant, the correlations are not exceptionally strong.

Research Question 7. For students with valid ACT scores, can separate multiple regression equations to predict final course grade in DSPM 0800, DSPM 0850, or MATH 1530 be developed using ACT composite scores, ACT mathematics, reading and English scores, high school GPA, number of high school mathematics classes taken, age at entry, and number of years since the last mathematics class as independent variables?

For DSPM 0800, with data available for 95 students, two possible models were possible using stepwise regression; both using variables related to the student's high school background. The first model gave the equation $\hat{y} = -.589(\text{HSMATH}) + 4.599$, where HSMATH represents the number of high school mathematics courses at the level of Algebra I or higher ($r^2 = .108$, $F = 11.225$, $p = .001$) and \hat{y} is the predicted grade. The second model incorporated both number of college preparatory mathematics classes (HSMATH) and overall high school grade point average (HSOGPA). The second regression equation was $\hat{y} = -.765(\text{HSMATH}) + 1.009(\text{HSOGPA}) + 2.298$. In this model, $r^2 = .256$, $F = 15.796$, and $p < .001$. [Table 11](#) shows the regression table for the two models.

For DSPM 0850, with data from 160 students, there were also two possible regression models. The first one was $\hat{y} = .364(\text{ACTM}) - 3.238$, where ACTM represents the student's score mathematics portion of the ACT ($r^2 = .110$, $F = 19.579$, $p < .001$). The second one was $\hat{y} = .301(\text{ACTM}) + .662(\text{HSOGPA}) - 4.111$, where the variables were the ACT

Table 11
Regression for DSPM 0800
(Students with ACT Scores)

Variable	<i>B</i>	<i>SE</i>	β
Model 1			
Constant	.803	.715	
High School GPA	.740	.252	.291
Model 2			
Constant	1.698	.726	
High School GPA	.963	.248	.379
Total number of high school mathematics classes taken	-.444	.130	-.333

mathematics score and overall high school grade point average ($r^2 = .172$, $F = 16.351$, $p < .001$). The regression table for these two is seen as [Table 12](#).

Four possible regression models resulted for MATH 1530, using the independent variables ACTM and HSOGPA as defined in the previous two courses, along with age in years (AGE) and ACT English score (ACTE). Another variable had been computed which gave a decimal value for the age (e.g. 19.56 years), but this seemed to have no additional beneficial effect. In all four models, which represented data from 475 students, the p -value was $< .001$. The first model was $\hat{y} = .134(\text{ACTM}) - .521$, with $r^2 = .233$, $F = 143.390$. The second model was $\hat{y} = .092(\text{ACTM}) + .771(\text{HSOGPA}) - 2.181$, in which $r^2 = .316$, $F = 108.940$. The third model obtained was

Table 12
Regression Table for DSPM 0850
(Students with ACT Scores)

Variable	<i>B</i>	<i>SE</i>	β
Model 1			
Constant	-3.238	1.411	
ACT mathematics score ^a	.364	.082	.332
Model 2			
Constant	-4.111	1.389	
ACT mathematics score ^a	.301	.082	.274
High School GPA	.662	.193	.256

^aACT mathematics score includes DSPP score converted from mathematics portion of SAT.

$\hat{y} = .103(\text{ACTM}) + .910(\text{HSOGPA}) + .108(\text{AGE}) - 4.953$; in this model $r^2 = .346$ and $F = 83.226$. Finally, the fourth model using the largest number of independent variables was

$\hat{y} = .089(\text{ACTM}) + .855(\text{HSOGPA}) + .105(\text{AGE}) + .025(\text{ACTE})$; for this model $r^2 = .353$ and $F = 64.084$. [Table 13](#) has the regression table for these four models.

Research Question 8. For students without valid ACT scores, can separate multiple regression equations to predict final course grade in DSPM 0800, DSPM 0850, or MATH 1530 be developed using COMPASS writing, reading comprehension, prealgebra and algebra scores, number of college preparatory high school mathematics classes taken, age at entry, and number of years since the last mathematics class as independent variables?

As mentioned before, students without valid ACT scores tended to be older than traditional age students, so there is more variability of age. They may

Table 13
Regression Table for MATH 1530
(Students with ACT Scores)

Variable	<i>B</i>	<i>SE</i>	β
Model 1			
Constant	-.521	.247	
ACT mathematics score ^a	.134	.011	.482
Model 2			
Constant	-2.181	.320	
ACT mathematics score ^a	.09205	.012	.331
High School GPA	.771	.102	.326
Model 3			
Constant	-4.887	.678	
ACT mathematics score ^a	.103	.012	.371
High School GPA	.900	.104	.380
Age ^b	.104	.023	.187
Model 4			
Constant	-4.900	.675	
ACT mathematics score ^a	.08845	.014	.318
High School GPA	.845	.106	.357
Age ^b	.100	.023	.181
ACT English score ^a	.02547	.012	.104

^a ACT score includes DSPP score converted from corresponding portion of SAT

^b Decimal age on August 30, 2004

have “stopped out” for a while or had a very long gap between their last mathematics course and the one in which they had enrolled in the fall of 2004.

For DSPM 0800, no regression equation was possible to predict end-of-semester grades based on the independent variables listed. Only 33 students had scores in all four areas of the COMPASS test. An attempt was made to fine-tune the equations by not using the COMPASS arithmetic scores or only using the COMPASS intermediate algebra scores, thus adding more students, but a regression equation was still not possible.

For the 23 students in DSPM 0850, a regression equation was possible using all the independent variables listed in the research question. That equation was $\hat{y} = .020(\text{COMW}) + 1.374$, where COMW represents the COMPASS writing score ($r^2 = .221$, $F = 5.941$, $p = .024$). A different regression equation resulted when the only COMPASS scores were used for the arithmetic and intermediate algebra scores. Making this change resulted in having 44 students, and the new equation was $\hat{y} = .023(\text{COMA}) + 1.730$, where COMA is the COMPASS arithmetic score ($r^2 = .190$, $F = 9.858$, $p = .003$). [Table 14](#) gives the summary regression table for this model.

For the 22 students enrolled in MATH 1530 who had COMPASS scores in all four areas, no regression equation was initially possible using all the variables listed. However, by not including writing and reading scores, but keeping all the other independent variables, a total of 51 students were represented and the regression equation obtained was $\hat{y} = .027(\text{COMA}) + .671$,

Table 14
Regression Table for DSPM 0850
(Students with COMPASS Scores)

Variable	<i>B</i>	<i>SE</i>	β
Constant	1.374	.584	
COMPASS writing score	.02037	.008	0.470

Table 15
Regression Table for MATH 1530
(Students with COMPASS Scores)

Variable	<i>B</i>	<i>SE</i>	β
Constant	.671	.372	
COMPASS arithmetic score	.02731	.006	.525

again with COMA representing the arithmetic score on the COMPASS ($r^2 = .276$, $F = 18.677$, $p < .001$). The regression table for this model is seen in [Table 15](#).

Summary

The research questions in this study looked for relationships between course grade and various independent variables that could be found about students prior to the beginning of the semester. This study also attempted to find equations which could predict a course grade for students in two developmental mathematics courses and one core mathematics course based on incoming information.

1. Although there was no significant correlation between ACT mathematics score and grade in elementary algebra, a correlation did exist for intermediate algebra and for probability and statistics.
2. No correlation could be found for the ACT reading score in elementary algebra, but a strong one did exist for intermediate algebra and probability and statistics.
3. The COMPASS intermediate algebra test score was significantly correlated only with grade in intermediate algebra, not with elementary algebra or probability and statistics.
4. The COMPASS reading score was significantly correlated with grade in the two developmental mathematics courses, but not in MATH 1530.
5. The number of college preparatory mathematics courses taken in high school was not significantly correlated to grade in DSPM 0800, but was in DSPM 0850 and MATH 1530.
6. Overall grade point average in high school (for students whose GPA was available) was significantly correlated with grade in all three courses studied.
7. More than one regression equation could be developed for predicting grade in each of the three courses for traditional age students. For DSPM 0800, the most involved equation was $\hat{y} = -.765(\text{HSMATH}) + 1.009(\text{HSOGPA}) + 2.298$. For DSPM 0850, the equation was $\hat{y} = .301(\text{ACTM}) + .662(\text{HSOGPA}) - 4.111$. An equation for

MATH 1530 was

$$\hat{y} = .089(\text{ACTM}) + .855(\text{HSOGPA}) + .105(\text{AGE}) + .025(\text{ACTE}).$$

8. For students with COMPASS scores, no prediction equation was possible for DSPM 0800. In DSPM 0850, a regression equation of $\hat{y} = .023(\text{COMA}) + 1.730$ was obtained. Finally, for MATH 1530, the resulting regression equation was $\hat{y} = .027(\text{COMA}) + .671$.

Chapter 5

Findings and Recommendations

Correlations were sought for various independent variables which could be determined for students before the semester began and grade at the end of the semester for two developmental mathematics courses and one core mathematics course. In addition, this study attempted to determine whether equations could be developed to predict a student's grade at the end of the semester in those three courses, perhaps to contribute to a method to target students who might need additional help or even to refine the placement process which determines in which course students should begin their study of mathematics at the university.

Conclusions and Discussion

For the elementary algebra course, DSPM 0800, very few of the variables studied seemed to have much correlation with a student's grade. The only one of six variables chosen for correlation which showed a definite relationship was the overall grade point average from high school. For younger students, neither the score on the mathematics nor the reading portion of the ACT assessment was significantly correlated; likewise, the corresponding scores for older students – scores on the intermediate algebra and reading portions of the COMPASS test – did not have a significant relationship with final grade. The number of college preparatory mathematics courses taken in high school did not correlate

significantly with course grade when all students were considered. However, the mathematics preparation in high school did enter into the regression equation for traditional age students, though not for nontraditional students who took the COMPASS test instead.

For the intermediate algebra class, DSPM 0850, course grade was significantly correlated with ACT mathematics and reading scores, COMPASS intermediate algebra and reading scores, number of college preparatory mathematics courses taken in high school, and overall high school grade point average. Traditional age students had a regression equation which used the ACT mathematics score and overall high school GPA. A regression equation to predict the grade of nontraditional students had only the arithmetic score on COMPASS as a predictor variable.

Some of the results of the current study agree with previous studies cited for developmental mathematics courses. Because of the difference in numbers of courses, a direct comparison cannot always be made. The finding that the ACT mathematics score (in reality the DSPP score, which also includes some SAT scores) is not significantly correlated with the grade in elementary algebra agrees with the findings of Long (2003); the correlation for intermediate algebra is in line with the findings of Lott (1990).

Individual subject scores for COMPASS were not mentioned in most of the works cited, but the finding of no correlation of elementary algebra grade with the COMPASS intermediate algebra test would tend to confirm the work of

Long (2003) and Lott (1990). Day (1997) found the relation between COMPASS and intermediate algebra inconclusive, whereas a significant correlation was noted here. High school mathematics preparation was shown to be related to grade in intermediate algebra as well as tending to be a predictor for traditional elementary algebra students' grades in this study, agreeing with the results of Branum (1990), Meeks (1989), Hutson (1999), and Marwick (2002).

Most undergraduate students at ETSU are required to take MATH 1530, probability and statistics, for their degree. A number of independent variables studied showed a significant correlation with end-of-course grade for this course. Traditional aged students exhibited a high correlation between course grade and both mathematics and reading scores on the ACT. No such correlation was found, however, for nontraditional students, who had COMPASS scores in intermediate algebra and reading. High school grade point average also showed a significant correlation with the grade for this course; it should be noted that almost all students for whom a GPA was available were younger students who had ACT scores. A regression equation to predict final course grade was possible for traditional students using their ACT mathematics and English scores, age, and high school grade point average. As with DSPM 0850, only the COMPASS arithmetic score appeared in a regression equation for older students.

Findings from this study for the probability and statistics class are similar to relationships found in other studies mentioned earlier which dealt with other introductory college mathematics courses. Entrance exam mathematics scores

(ACT or SAT) in this study were found to be significantly correlated with the grade in MATH 1530, as they were for the elementary statistics class studies by Yablonsky (1989) and in other courses such as college algebra in the studies of Jackson-Teal (1990), Osborn (2002), and Blansett (1988). The intermediate algebra score on COMPASS was found to be significantly correlated with MATH 1530 grade here as with similar findings by Darbro (2002), Garcia (1998), and Preast (1998). However, the COMPASS reading score was not significantly related to grade in MATH 1530, in contrast to Preast's findings of a relation between TASP reading scores and college algebra grades.

Recommendations for Action

For students with recent ACT or SAT scores, regression equations were possible to predict the grades of students in each of the three courses studied. Some incoming students will have scores which are right on the borderline for placement in one course or another. For those students especially, it is recommended that the regression equations found in this study be used to predict the grade for each of those students using the variables indicated. All of these variables are readily found in SIS. If a student's predicted grade is below 2.0 (C) for either of the developmental classes or failing for probability and statistics, advisors should be encouraged to talk with such a student and suggest the possibility of moving down to the previous course. If such a move is not possible or practical, it is recommended that advisors and faculty target such students for additional help. For example, if a student whose grade is predicted

to be unsatisfactory misses more than one or two classes, a faculty member or academic advisor might discuss attendance and study habits with the student, or refer the student to the mathematics lab for additional help. Students in MATH 1530 could also be referred to Supplemental Instruction classes, an option not currently available in developmental classes at ETSU. Students eligible for other types of help such as individual academic tutoring could be strongly encouraged to take advantage of such services. Some faculty members might even require a student predicted to be in danger of failing to get additional outside help if the student's first test grade is unacceptable.

For nontraditional students, fewer practical recommendations can be made based on the results of this study. No regression equation was possible for students taking DSPM 0800. For the other two classes, the COMPASS intermediate algebra score determines the placement, and only the COMPASS arithmetic score entered into any kind of prediction equation. However, students whose arithmetic score might predict an unsuccessful experience in DSPM 0850 or MATH 1530 could be targeted for additional help in the same ways outlined above for traditional students. Even with no regression equation possible for DSPM 0800, students with low COMPASS arithmetic scores should still be watched closely to be ready to intervene and help them succeed. Informal discussion with some adult students indicates that some students worry that they guessed their way into a higher placement than they felt prepared for. Unfortunately, no research seems readily available to determine whether this is

true. (Perhaps this would be a useful topic of research for another future study.) At the very least, a further informal assessment of a nontraditional student's mathematics background would be indicated.

Recommendations for Future Research

No study dealing with academic achievement can claim to be the last, definitive word on its subject. Standards change, the makeup of the student body changes, the political climate changes, and curriculum changes. Consequently, this study is nothing more than a snapshot in time. Additional areas for further research can be suggested from the findings or by new information that came to light after a study is begun, and this study is no exception.

One particularly puzzling result finding of this study was that of a negative correlation between the number of high school college preparatory mathematics classes taken by traditional-age students and grade in elementary algebra. One would not expect that a theoretically better preparation for college would result in a lower grade in a developmental mathematics course. Yet this peculiar finding appeared both in a correlation and regression equation. Though not at all statistically significant, a negative correlation was also found for older students. Future research should examine this result to determine if this was an anomaly peculiar to the Fall, 2004, semester, or a common occurrence. A repeat of this finding might suggest some kind of disturbing trend in the learning of

recent high school graduates who are among the most at-risk academically in college.

The current study was conducted in the fall. Students taking the course in spring or summer semesters might generate different results. In fact, at least in the developmental courses, it is quite likely that the results would be different for a different semester. An earlier study of several years' worth of developmental mathematics grades at ETSU (Hopkins & Stephens, 2002) showed that students' grades in summer were significantly higher than in fall, and fall grades were significantly higher than in spring. It was speculated that this grade discrepancy occurred because students enrolling in the summer and fall semesters, especially in DSPM 0850, were perhaps better prepared than their classmates who had to take a second course in the spring semester or first enrolled in the spring semester. It is unknown if a similar study exists for the probability and statistics course. Therefore it is recommended that similar research be conducted on students in all three courses in spring and summer semesters.

Certain data categories were not included in the course of the study which, in retrospect, might have led to different results. Students who were repeating the course were treated no differently from those taking the course for the first time. Perhaps a similar future study should filter out repeaters or contrast the results of repeaters versus first-timers. A side study, perhaps qualitative, might examine characteristics of repeaters to determine whether any

commonalities exist among students who are taking the course for a second or third time. Some other related questions arose in collecting data:

While examining transcripts to obtain other data, it was noted that a number of students had taken other college-level mathematics courses before taking MATH 1530. Would the number of college-level mathematics courses such as college algebra, precalculus, or calculus have any value in predicting grades in MATH 1530?

Would the regression equations be different for the courses studied if another variable, the number of previous developmental mathematics courses taken, had been added? Politicians and other policy makers often have been known to ask whether developmental education is a worthwhile endeavor. Is there a difference in achievement in MATH 1530 between students who took developmental courses and those who did not? Would there be a relation between grade in MATH 1530 and the number of other developmental courses taken (writing, reading, and learning strategies)?

Two other developments under recent discussion might lead to additional areas for research. Other institutions in the Tennessee Board of Regents system allow a number of other courses to count for a bachelor's degree, such as precalculus algebra (MATH 1710), precalculus trigonometry (MATH 1720), structure of the number system (MATH 1410-1420), and contemporary mathematics or mathematics for liberal arts (MATH 1010). If ETSU changed degree requirements to allow these other courses to count towards graduation,

would the correlations and regression equations for those courses (and for MATH 1530) be different? One would expect that a smaller, qualitatively different group of students would be taking MATH 1530 if such a change were to take place. In such a case, this study could be repeated for each of the courses which were allowed to be used for graduation requirements.

Another area which has sometimes been discussed among developmental studies program directors in Tennessee – and perhaps other states – is whether to raise the ACT cutoff scores for placement into developmental mathematics courses. If the cutoff scores are different, then certainly many of the results of this study would be different. Conceivably, the results of this and other similar studies could help set an optimal cut off score. ACT (1997) suggests, based on its studies, using a mathematics score of 22 as the dividing line between a student taking developmental or freshman-level courses. A higher cutoff score would, of course, result in more students being enrolled in developmental courses before taking their core-level course. A study which only looked at students who are in their first mathematics course at ETSU, whether it be a DSPM or MATH course, might help determine whether raising the cutoff score would increase probability of achievement in these courses.

Finally, one question for future research was posed by a student. This particular student noted that when he was in high school several decades ago, he felt that he was given very little guidance in selecting math courses. A qualitative study involving interviewing several students might shed some light

on past reasons for taking or not taking various mathematics courses in high school. Perhaps other students might feel, as did that student, that they were not encouraged to take college preparatory mathematics. If this were still true for more recent high school graduates, such a study might inform communication between high schools and colleges on expectations of both students and higher education institutions.

Obviously, more factors influence the grade of a student in a college mathematics class besides previous performance. Certainly, attendance, attitude, effort, anxiety levels, learning styles, personal issues, and perhaps even odd factors such as the time of day the student takes the class may have a larger effect on a student's performance than the variables considered in this study. Many of the factors found to be related to performance in the class were not strongly related. However, any easily obtained information that can help instructors and students work together to ensure student success is at least of some worth.

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Appendices

Appendix A

Survey Given to Students

Survey on High School Mathematics Background

Informed Consent

I understand the purpose of the project and agree to allow Mr. Stephens to use the information described.

Signature Date

Print your name_____

To the best of your recollection, in what year did you take your last mathematics class in high school?

Please list the mathematics classes you took and passed in high school.

___ Did not attend high school.

___ GED mathematics course(s)

Appendix B

Informed Consent Form Given to Students

Survey on High School Mathematics Background

You are invited to participate in a research survey called "Predicting Success of Developmental and Core Mathematics Students at East Tennessee State University" done by Mr. Daryl Stephens, assistant professor of mathematics here at ETSU, for his dissertation at the University of Tennessee-Knoxville. The purpose of this study is to find a way of predicting a student's grade in a statistics or developmental mathematics class based on ACT or COMPASS scores, age, years since the last high school mathematics class, number of mathematics classes taken in high school, and high school grade point average. This research may help improve the placement process for future ETSU students who may have to take these classes and identify which students may need more help.

If you agree to participate, your involvement would consist of filling out the survey you were given, which should take about a minute to fill out. Mr. Stephens will then look up the other information (ACT or COMPASS scores, high school grade point average) on the campus computer system. Besides the information you supply on the survey, Mr. Stephens will also use the university student information system to obtain your ACT or COMPASS scores, age, and high school grade point average. At the end of the semester, he will get the grade you make in this course from your instructor. Again, all this information is confidential and will be used to make one big set of data. Beyond filling out the information below, no other action is needed on your part.

Your participation in this survey is entirely voluntary and will not affect your grade in this course in any way. There are no known risks associated with this research. All information you list on this survey will be confidential. Completed surveys and computer records will be locked away to maintain confidentiality. Only Mr. Stephens and his dissertation committee will have access to individual information. The published form of his dissertation will not involve any information about individual students. The results will involve only a summary of information on all students in the courses who elect to participate.

Your participation in this study is voluntary; you may decline to participate without penalty. If you prefer not to participate in this study, just don't return this form. If you decide to participate, you may withdraw from the study at any time. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed. Return of the completed survey constitutes your consent to participate. Please do not participate if you are younger than 18.

If you have any questions, you may contact Mr. Stephens at (423) 439-4676 (e-mail stephen@etsu.edu), or drop by his office in Rogers-Stout 306. If you have questions about your rights as a participant, contact the UT-Knoxville Research Compliance Services at (865) 974-3466.

Appendix C

Letter Requesting Participation by Faculty

October 12, 2004

Dear Colleague,

I would like to ask you for your help. As you may know, I'm finishing up my dissertation this year. Part of it requires collecting data from students taking developmental math and MATH 1530 classes this semester. Most of it is available on SIS, but I need two pieces of information that are not on SIS.

Some time during the month of October (or the first week of November) at your convenience, could you pass out the surveys in the enclosed envelopes to the class listed on the envelope? They should only take about 5 minutes to complete. To completely comply with regulations involving human subjects research, I have also included a handout telling students no harm will come to them by participating in the research. (That's assuming no one gets a paper cut, of course!)

Students can keep the information sheet and give back the survey sheet. No one should be forced to participate, of course. Any student younger than 18 should not fill out the survey due to more stringent regulations concerning them.

If you have any questions, or you would like for me to come to your class to give out the survey, please let me know. My phone number is 9-4676, and my e-mail is stephen@etsu.edu.

Please place the completed survey forms in the envelope they came in and put them in my box.

Thanks!

Daryl Stephens
assistant professor

Vita

Daryl Stephens was born in 1961 to Elvis and Joyce Stephens, who had both been first-generation college students. He graduated from Denton (Texas) High School in 1979. He received his bachelor of science in education degree from North Texas State University (now the University of North Texas at Denton) in 1983 with a major in elementary education and a minor in mathematics.

That same year he began his teaching career in the McKinney (Texas) Independent School District, teaching seventh grade math for five years and then fifth grade math and science for two more years. He also obtained a master of education degree from NTSU in 1987 with a major in public school administration.

From 1990 to 1993 he was a master's student at Texas Woman's University majoring in mathematics. During that time he served as a graduate teaching assistant, then as an adjunct instructor in the summer of 1993 after receiving his master of science degree. During his last year at TWU, he also taught mathematics courses part-time at off-campus sites of Cooke County College (now North Central Texas College) and the Northeast Campus of Tarrant County Junior College (now Tarrant County College).

In the 1993-94 academic year he was a full-time temporary instructor in the Department of Developmental Studies at Macon College (now Macon State

College). In 1994 he accepted a position as a mathematics instructor in the Division of Developmental Studies at East Tennessee State University, reaching the rank of tenured assistant professor in 1999. As part of the university's reorganization due to state budget cuts, he was transferred to the mathematics department in 2003.

Mr. Stephens is a member of the National Association for Developmental Education and has served for several years as the vice-chair or chair of the mathematics special professional interest network ("Math SPIN"). He is also a member of the Tennessee Association for Developmental Education and served on its executive board in 2003-04. He has made several presentations at conferences of both organizations. For 2005-06 he is the president-elect of the Upper East Tennessee Council of Teachers of Mathematics. Other professional organization memberships include the National Council of Teachers of Mathematics, Tennessee Mathematics Teachers Association, American Mathematical Association of Two-Year Colleges, and Tennessee Mathematical Association of Two-Year Colleges.